PB-218 404

# WATER SUPPLY AND WATER QUALITY CONTROL STUDY, SPRING RIVER BASIN, KANSAS, MISSOURI, AND OKLAHOMA

Federal Water Pollution Control Administration
Dallas, Texas

March 1968

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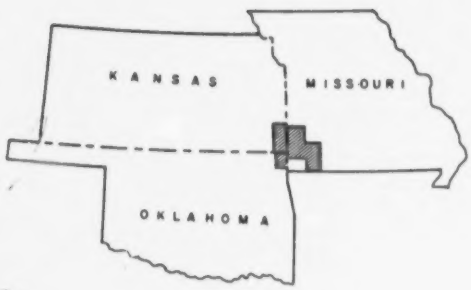
PB 218 404

# WATER SUPPLY AND WATER QUALITY CONTROL STUDY SPRING RIVER BASIN KANSAS, MISSOURI, AND OKLAHOMA

**Study of Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control**

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**UNITED STATES DEPARTMENT OF THE INTERIOR**
**Federal Water Pollution Control Administration**
**South Central Region**
**Dallas, Texas**

**MARCH 1968**

43

# WATER SUPPLY AND WATER QUALITY CONTROL STUDY

# SPRING RIVER BASIN

# KANSAS, MISSOURI, AND OKLAHOMA


## ABSTRACT

An investigation has been made to determine the need for and value of storage for water supply and water quality control in the Spring River Basin. This investigation discloses that storage to increase the dependable water supply yield of the basin and to augment low flows for pollution abatement would be highly desirable.


Prepared for

DEPARTMENT OF THE ARMY

U.S. Army Engineer District

Tulsa, Oklahoma


UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
South Central Region
Dallas, Texas

MARCH 1968

TABLE OF CONTENTS


| | | Page |
|---|---|---|
| LIST OF TABLES | | ii |
| LIST OF FIGURES | | iii |
| I. | INTRODUCTION | |
| | Request and Authority | I-1 |
| | Purpose and Scope | I-1 |
| | Acknowledgments | I-1 |
| II. | SUMMARY OF FINDINGS AND CONCLUSIONS | |
| | Summary of Findings | II-1 |
| | Conclusions | II-1 |
| III. | PROJECT DESCRIPTION | III-1 |
| IV. | STUDY AREA DESCRIPTION | |
| | Location and Boundaries | IV-1 |
| | Characteristics | IV-1 |
| V. | WATER RESOURCES OF THE STUDY AREA | |
| | Streamflow | V-1 |
| | Ground Water | V-2 |
| | Water Quality | V-3 |
| VI. | THE ECONOMY | |
| | Present | VI-1 |
| | Future | VI-5 |
| VII. | WATER REQUIREMENTS | |
| | Present Water Use | VII-1 |
| | Future Water Use | VII-1 |
| VIII. | WATER QUALITY CONTROL | |
| | Turkey Creek | VIII-1 |
| | Center Creek | VIII-3 |
| | Summary | VIII-5 |
| IX. | BENEFITS | |
| | Water Supply Benefits | IX-1 |
| | Water Quality Control Benefits | IX-1 |
| | Single-Purpose Reservoir Alternate | IX-2 |
| | Advanced Waste Treatment Alternate | IX-2 |
| X. | BIBLIOGRAPHY | X-1 |

LIST OF TABLES


| Number | Title | Page |
|---|---|---|
| III-1 | Principal Features - Prosperity Reservoir. . . . . | III-1 |
| V-1 | Summary of Streamflow Records Spring River Basin . . . . . | V-1 |
| V-2 | Water Quality Summary Spring River Basin . . . . . | V-3 |
| V-3 | Water Quality Analysis Center Creek and Turkey Creek . . . . . | V-4 |
| VI-1 | 1960 Population of Urban Areas Spring River Basin . . . . . | VI-1 |
| VI-2 | Study Area Populations Total, Urban, and Rural 1940, 1950, and 1960 . . | VI-2 |
| VI-3 | Agricultureal Statistics for the Study Area 1959 and 1964 . . . . . | VI-3 |
| VI-4 | Study Area Labor Force and Population 1950 and 1960 . . . . . | VI-5 |
| VI-5 | Spring River Study Area Labor Force Projections 1960, 2000, and 2025 . . | VI-6 |
| VI-6 | Spring River Study Area Population Projections 2000, 2025, and 2075 . . . . . | VI-7 |
| VII-1 | 1962 Municipal Water Use . . . . . | VII-2 |
| VII-2 | Municipal Water Use Projections . . . . . | VII-3 |
| VII-3 | Industrial Water Use Projections . . . . . | VII-4 |
| VII-4 | Municipal and Industrial Water Supply Plan . . . . | VII-4 |
| VIII-1 | Water Quality Control Requirements Turkey Creek . . . . . | VIII-2 |
| VIII-2 | Water Quality Control Monthly Release Schedule for Turkey Creek . . . . . | VIII-2 |
| VIII-3 | Water Quality Control Requirements Center Creek . . . . . | VIII-4 |

LIST OF TABLES (Continued)


| Number | Title | Page |
|---|---|---|
| VIII-4 | Water Quality Control Monthly Release Schedule for Center Creek . . . . . | VIII-5 |
| IX-1 | Treatment Requirements Turkey Creek . . . . . | IX-3 |


LIST OF FIGURES


| Number | Title | Following Page |
|---|---|---|
| III-1 | Location Map . . . . . | X-4 |
| V-1 | Annual Mean Flow Frequency . . . . . | V-2 |
| V-2 | Monthly Distribution of Annual Flow . . . . . | V-2 |

# I. INTRODUCTION

## Request and Authority

The District Engineer, U. S. Army Engineer District, Tulsa, Oklahoma in a letter dated July 17, 1964, requested the advice of the U. S. Department of Health, Education, and Welfare concerning the needs for storage for water supply and water quality control in the Spring River basin, Kansas, Missouri, and Oklahoma, and the value of benefits resulting therefrom.

The water supply portion of this study was made in accordance with the Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare relative to the Water Supply Act of 1958, as amended. The water quality control aspects are considered under authority of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.). Responsibility for these activities was transferred from the Department of Health, Education, and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

## Purpose and Scope

The purpose of this study is to determine the need for and value of storage for water requirements to the year 2075 for municipal, industrial, and water quality control purposes in the Spring River basin. The study area includes the counties which encompass the Spring River basin drainage area: Ottawa County, Oklahoma; Crawford and Cherokee Counties, Kansas; and Barry, Barton, Jasper, Lawrence, and Newton Counties, Missouri.

## Acknowledgments

Appreciation is expressed to the following organizations who provided information and technical advice during the preparation of this report:

U. S. Army Corps of Engineers, Tulsa District Office
U. S. Geological Survey
Missouri Water Pollution Board
Missouri Water Resources Board
Missouri Geological Survey
Kansas State Department of Health
Kansas Water Resources Board
Oklahoma Water Resources Board
Oklahoma State Department of Health
Various municipal and industrial officials in the study area

# II. SUMMARY OF FINDINGS AND CONCLUSIONS

## Summary of Findings

1. The Corps of Engineers, Tulsa, Oklahoma, is conducting a water resources study of the Spring River basin and of Prosperity Reservoir on Center Creek, a tributary to Spring River in extreme southwestern Missouri.

2. The study area, encompassing the Spring River basin, comprises eight counties in southwestern Missouri, southeastern Kansas, and northeastern Oklahoma.

3. The study area had a total population of 249,862 in 1960. The largest municipality in the area is Joplin, Missouri, with a 1960 population of 38,958. The total population has been declining in recent years due to a greater rural decline offsetting a slight urban increase.

4. The major industries in the basin are food and kindred products and chemical manufacturing. Lead and zinc mining, the prime industry in the past, is now of minor importance.

5. In general, the quality of surface water in the Spring River basin is very good. However, two tributary streams, Center Creek and Turkey Creek, are presently being degraded by industrial and municipal effluents.

## Conclusions

1. The study area population is expected to increase moderately in the future as the rural decline ceases and the urban population increases. Total population is projected to be 400,000 by the year 2025 and 640,000 by 2075.

2. Projections to the year 2075 indicate that an additional source of municipal and industrial water supply amounting to 27 million gallons per day (mgd) will be needed in the Joplin area to satisfy the water supply demand.

3. Storage is needed in the study project for water quality control on Center and Turkey Creeks. Storage to yield 31.4 mgd will satisfy the quality needs to through the year 2075. The water quality yield of the project under study (25.5 mgd) will satisfy the needs through the year 2060.

4. The annual value of benefits attributable to storage for municipal and industrial water supply in the study project is estimated at $290,700, based on the cost of the most likely alternate, a single-purpose water supply reservoir on Shoak Creek.

5. The annual value of benefits attributable to storage for water quality control in the study project is estimated at $187,900, based on the cost of the least costly alternate, advanced waste treatment. The value of benefits attributable to storage and transmission facilities from Prosperity Reservoir to Turkey Creek is estimated at $265,500 annually.

6. Benefits to storage for water quality control in the proposed project are considered to be widespread in scope and are based on the provision of secondary or equivalent treatment being provided to wastes discharged to affected stream reaches.

# III. PROJECT DESCRIPTION

The project under study is the Spring River basin and the multi-purpose Corps of Engineers' reservoir to be located at river mile 18 on Center Creek in extreme western Missouri. (See the location map, figure III-1, at the end of this report.)

Principal features of the reservoir are shown below in table III-1.

Table III-1

Principal Features - Prosperity Reservoir

| | |
|---|---|
| Location: | Center Creek, Missouri |
| River Mile: | 18.0 |
| Storage, acre-feet | |
| Flood Control | 84,000 |
| Water Supply | 64,000 |
| Water Quality Control | 88,000 |
| Inactive & Sediment | 10,500 |
| Total | 246,500 |
| Dependable Yield, mgd | |
| Water Supply | 27.0 |
| Water Quality Control | 25.5 |

Source: Corps of Engineers[1/]

# IV. STUDY AREA DESCRIPTION

## Location and Boundaries

The study area consists of the eight counties which encompass the Spring River basin, which are: Barry, Barton, Jasper, Lawrence, and Newton Counties, Missouri; Crawford and Cherokee Counties, Kansas; and Ottawa County, Oklahoma. As shown in figure III-1, the Spring River basin is located at the common border of the States of Kansas, Missouri, and Oklahoma. Joplin, Missouri is approximately in the center of the basin.

## Characteristics

The Spring River basin, located in the foothills of the Ozark Mountains, has a mild climate with an average rainfall of approximately 40 inches per year. Agriculture, light manufacturing, and tourism are the primary economic activities. The mining of lead and zinc, once the major economic pursuit in the area, is now of minor importance.

A study of the population trends in the areas reveals a declining rural population and a slightly increasing urban population, with the total population showing a net loss. This trend is characteristic of agricultural areas as small, unprofitable farms are being abandoned or absorbed by larger farms with the farm population moving into towns or major cities to seek other employment. In the Spring River basin study area, the decline of mining activity also has had a disastrous affect on job opportunities and thus population growth.

Joplin, Missouri is the hub of economic activity in the study area. It's 1960 population was 38,958.[2/] Other major towns in the study area are: Carthage and Neosho, Missouri; Pittsburg, Kansas; and Miami, Oklahoma.

# V. WATER RESOURCES OF THE STUDY AREA

The Spring River rises in the Ozark Mountains near Aurora, Missouri and flows north, west, then south approximately 110 miles to join the Grand (Neosho) River in the headwaters of Pensacola Reservoir, a Grand River Dam Authority reservoir used for flood control, hydroelectric power generation, and recreation. Spring River drains a total area of 2,581 square miles.[3/] Major tributaries are North Fork Spring River, Cow Creek, Center Creek, and Shoal Creek.

There are no major reservoirs in the basin. A 22-foot high dam on Spring River near Riverton, Kansas is owned by the Empire District Electric Company and is utilized for minor hydroelectric power generation but primarily as a source of cooling water for a thermo-electric generating plant at Riverton.

Most of the base flow of Spring River is contributed by springs in the headwaters of the main stem and Missouri tributaries, particularly Shoal Creek.

Ground water is abundant and utilized by most communities as a source of water supply. Mine water in abandoned lead and zinc mines is also used by several major industries in the Joplin area as a source of cooling water.

## Streamflow

Presented below in table V-1 is a summary of streamflow records at three locations in the Spring River basin.

Table V-1

Summary of Streamflow Records
Spring River Basin

| Location | Years of Record | Drainage Areas (sq.mi.) | Streamflow (cfs) Annual Average | Maximum | Minimum |
|---|---|---|---|---|---|
| Spring River near Quapaw, Okla. | 26 | 2,510 | 1,888 | 190,000 | 5.8 |
| Spring River near Waco, Missouri | 41 | 1,164 | 823 | 103,000 | 4.2 |
| Shoal Creek above Joplin, Missouri | 24 | 410 | 376 | 62,100 | 12 |

Source: Geological Survey[4/]

It is of significance that zero flows have not occurred at these three locations over the period of record, even though zero flows are common on many streams immediately west of the Spring River basin in Kansas and Oklahoma. Ground water seepage and spring inflow account for a large portion of the base flow in the study area.

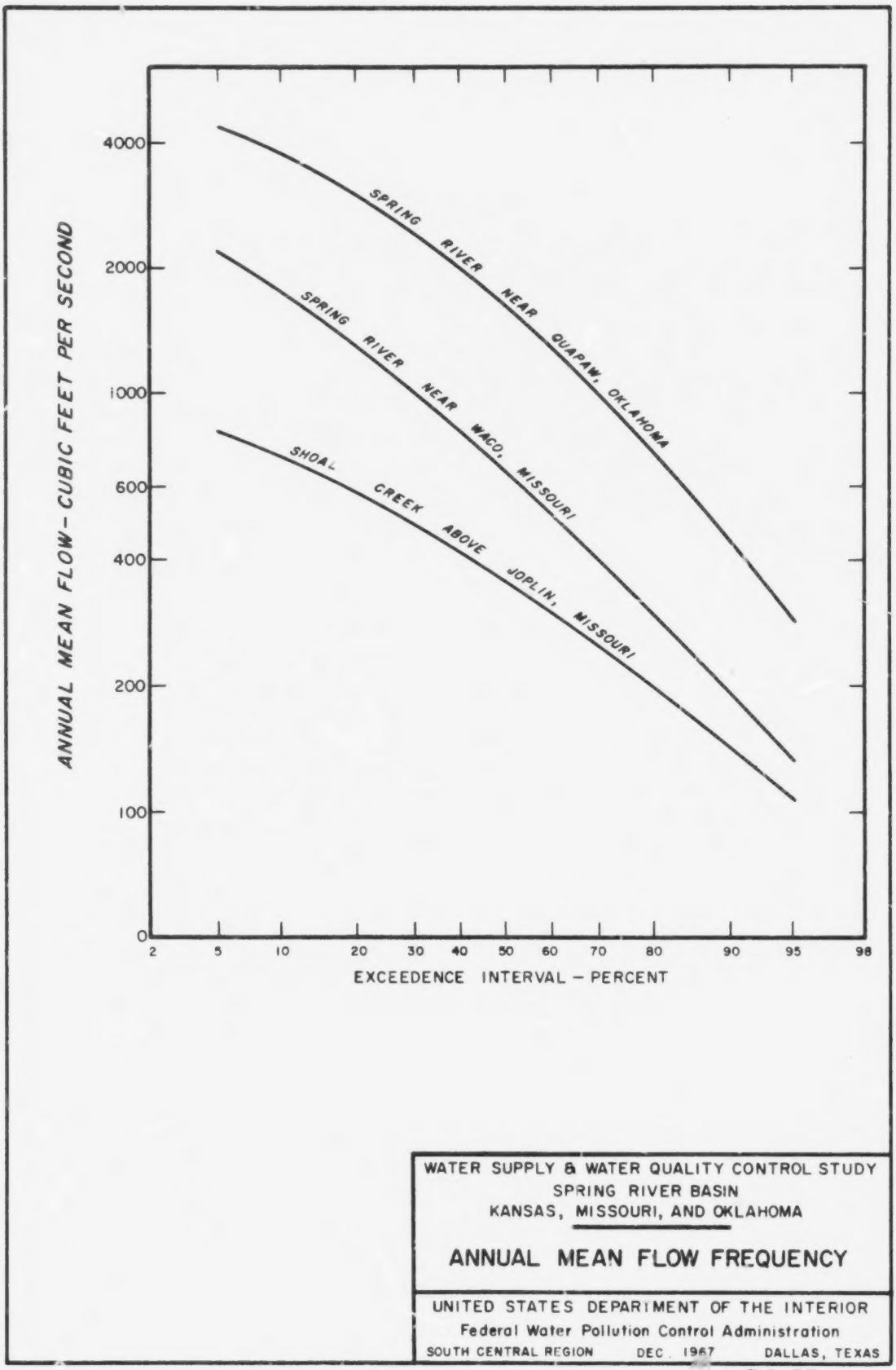
Figures V-1 and V-2 show the annual mean flow frequency and the monthly distribution of annual flow, respectively, of Spring River near Waco, Missouri and Quapaw, Oklahoma, and Shoal Creek above Joplin, Missouri. Larger spring-fed base flows on Shoal Creek is evidenced by a lesser slope in figure V-1 and a more uniform distribution of annual flows on figure V-2.

## Ground Water

Water levels are close to the surface near main streams, are generally 50 to 150 feet deep away from the streams but are 200 feet deep away from streams in the Joplin area where pumping from mines is presently concentrated.[5/] Many communities in the study area use ground water as their source of water supply. However, large water uses in the area, such as the city of Joplin, must depend on surface waters because of relatively low yield from deep wells.

The following figures are average generalizations for wells approximately 1,400 feet deep with an average drawdown of 100 feet.[6/] Such a well in the Joplin area produces 120 gallons per minute; a well in the Carthage vicinity, 280 gallons per minute; and one at Mt. Vernon produces 360 gallons per minute.

Mine yields vary considerably depending on inflow rates. Yields of mines pumped continuously for industrial water supply range from less than 100 gallons per minute to 1,000 gallons per minute. In 1964 about 2,500 gallons per minute was pumped continuously from mines in the Oronogo-Duenweg belt. During World War II, pumping capacity of 14,000 gallons per minute was required to keep the mines dewatered, according to water level and pumpage rate to keep the water level below the mine workings, but at times of heavy rainfall pumping rates were as high as 56,000 gallons per minute. On the basis of the inflow to Center Creek, which is about 2,700 gallons per minute in the dry season of the year, it is believed that a pumping rate of 5,000 gallons per minute from the mines can be sustained without seriously lowering of the piezometric surface.[5/]

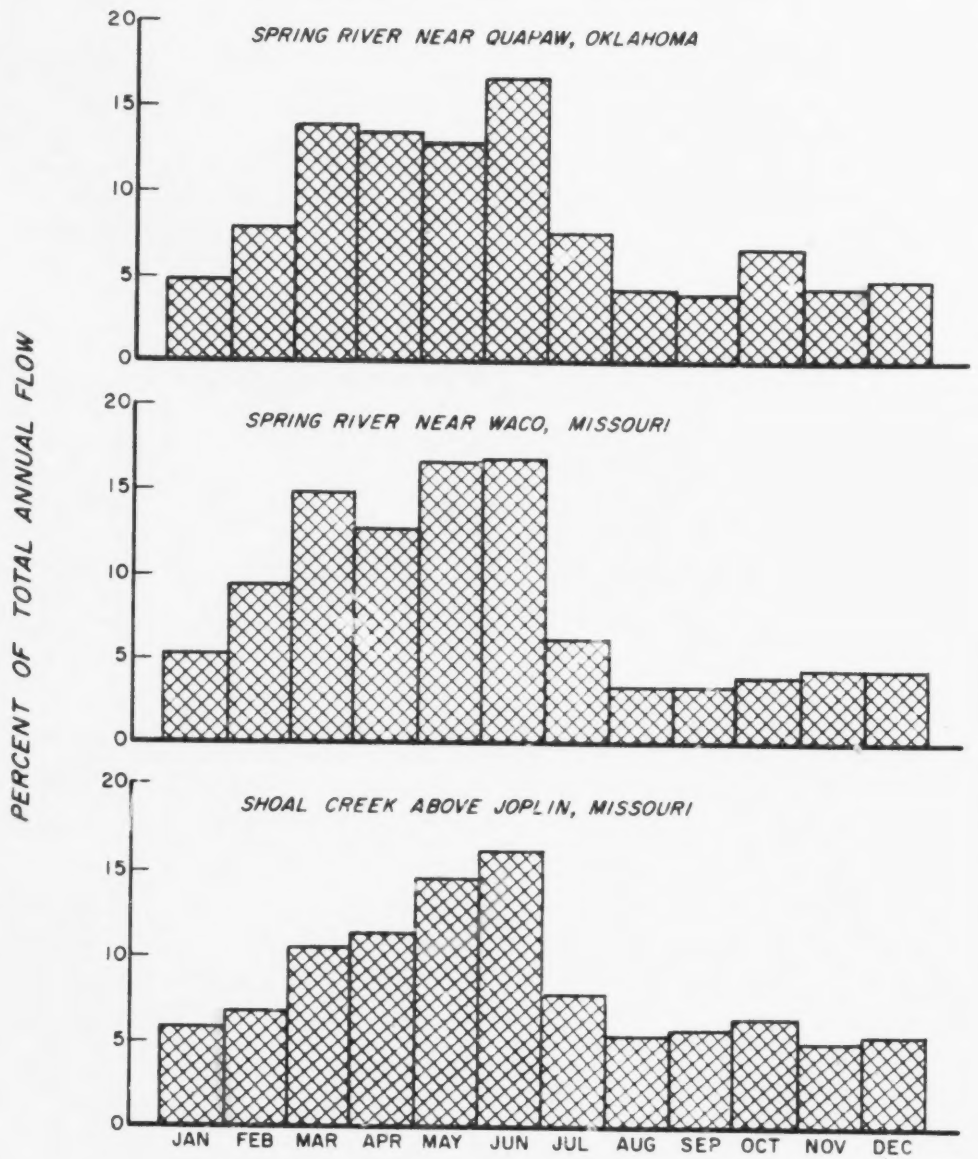



WATER SUPPLY & WATER QUALITY CONTROL STUDY
SPRING RIVER BASIN
KANSAS, MISSOURI, AND OKLAHOMA

ANNUAL MEAN FLOW FREQUENCY

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION DEC. 1967 DALLAS, TEXAS

FIGURE V-1




WATER SUPPLY & WATER QUALITY CONTROL STUDY
SPRING RIVER BASIN
KANSAS, MISSOURI, AND OKLAHOMA

MONTHLY DISTRIBUTION OF ANNUAL FLOW

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION DEC. 1967 DALLAS, TEXAS

FIGURE V-2

## Water Quality

### Surface Water

The quality of surface water in the Spring River basin, as shown below in table V-2, is acceptable for most municipal and industrial uses.

Table V-2

Water Quality Summary
Spring River Basin

| Location | Sample Period | Average Flow (cfs) | Arithmetic Mean (mg/1) $SO_4$ | Cl | DS | Hardness |
|---|---|---|---|---|---|---|
| Spring River near Baxter Springs, Kansas | 10/62 to 9/63 | 681 | 61 | 12 | 260 | 267 |
| | 10/63 to 9/64 | 482 | 79 | 20 | 307 | 303 |
| Shoal Creek above Joplin, Missouri | 9/62 to 8/6[illegible] | 208 | 8 | 6 | 155 | 146 |

Source: Geological Survey[7,8]

Although the main stem and most tributaries of Spring River are not affected by natural or man-made pollution, two streams in the basin are degraded by municipal and industrial waste discharges and mine drainage. Center Creek receives the wastes of several chemical (fertilizer and explosive) plants which contain high concentrations of ammonia, nitrates, nitrites, orthophosphates, and fluorides.[9] Fluoride levels as high as 40 mg/l[10] have been recorded. Several fish kills were reported in Center Creek in 1965 and 1966 attributed to chemical pollution.[11] Zinc contributed from natural drainage from abandoned lead and zinc mines and mine water used by industries for cooling appears in Center Creek in concentrations averaging from 0.5 mg/l to 1.5 mg/l, although concentrations on Grove Creek, a tributary to Center Creek, have ranged as high as 9.7 mg/l.[12]

Turkey Creek receives the treated effluent from the city of Joplin. Frequently, the flow in Turkey Creek is too small to

assimilate wastes discharged to it without impairment of water quality and desirable stream conditions, as evidenced by low dissolved oxygen levels caused by decomposition of organic wastes.

Table V-3 is a summary of stream quality conditions on Center and Turkey Creeks from samples taken from August 1963 to September 1964. The quality of Center Creek above Grove Creek indicates the good quality water to be stored in the proposed reservoir. The quality of Center Creek near Carterville (below Grove Creek), when contracted with the records above Grove Creek, shows the effects of industrial pollution.

Table V-3

Water Quality Analysis
Center Creek and Turkey Creek

| | Center Creek near Carterville | | | Center Creek above Grove Creek | | | Turkey Creek near Joplin, Missouri | | |
|---|---|---|---|---|---|---|---|---|---|
| Element | Mean | Max. | Min. | Mean | Max. | Min. | Mean | Max. | Min. |
| Discharge | 41 | 96 | 18 | 56 | 110 | 34 | 18 | 57 | 5.6 |
| Sulfate | 129 | 213 | 41 | 6.7 | 8.0 | 5.6 | 157 | 225 | 108 |
| Chloride | 14 | 22 | 7.1 | 4.3 | 4.9 | 3.0 | 39 | 67 | 18 |
| Dissolved Solids | 383 | 537 | 220 | NA | NA | NA | 489 | 610 | 325 |
| Hardness (carbonate) | 230 | 307 | 151 | 137 | 145 | 121 | 293 | 367 | 208 |
| Fluoride | 16 | 40 | 4.7 | 0.1 | 0.2 | 0 | 0.4 | 0.6 | 0.1 |
| Nitrate | 47 | 88 | 24 | 1.7 | 2.5 | 0.8 | 9.3 | 26 | 0.7 |
| Zinc | .94 | 1.50 | .06 | NA | NA | NA | .44 | 1.10 | .16 |
| Dissolved Oxygen | 9.1 | 13.9 | 5.7 | 10.9 | 14.4 | 7.8 | 7.2 | 11.2 | 1.0 |
| pH | 6.9 | 7.7 | 4.8 | 8.1 | 8.1 | 8.0 | 7.8 | 8.1 | 7.3 |

NOTE: Quantities measured in mg/l except Discharge (cfs) and pH.

Source: Geological Survey[9,10/]

## Ground Water

Although extensive quality data for ground water are not available, limited analyses[13/] available on municipal ground water are similar to surface water in the basin and acceptable for most municipal and industrial uses. Water in mine shafts, some of which is used for industrial cooling, contain higher concentrations of dissolved solids than surface waters. Analyses of water in 19 mine shafts near Joplin[12/] show zinc content ranging from 0.5 mg/l to 35 mg/l, with a median concentration of 10 mg/l. The specific conductance of mine waters in the area ranges from 514 to 2,200 and averages 1,400 michromhos.[5/]

# VI. THE ECONOMY

An economic evaluation was made of the 8-county Spring River basin study area. The resulting projections of population and industrial growth serve as a basis for estimating future water use requirements and subsequent waste discharges.

## Present

### Economic Geography

The study area covers portions of southwestern Missouri, northeastern Oklahoma, and southeastern Kansas. Joplin, Missouri, Pittsburg, Kansas, and Miami, Oklahoma are the largest cities in the area. The 8-county study area had a 1960 population of 249,862.[2/] Table VI-1 includes all the urban towns in the area and their 1960 population. Urban, rural, and total population for each county in the study area are shown in table VI-2.

Table VI-1

1960 Population of Urban Areas
Spring River Basin

| State | Community | 1960 Population |
|---|---|---|
| Missouri: | | |
| | Joplin | 38,958 |
| | Carthage | 11,264 |
| | Neosho | 7,452 |
| | Webb City | 6,740 |
| | Aurora | 4,683 |
| | Monett | 4,115 |
| | Lamar | 3,608 |
| Oklahoma: | | |
| | Miami | 12,869 |
| | Picher | 2,553 |
| Kansas: | | |
| | Pittsburg | 18,678 |
| | Baxter Springs | 4,498 |
| | Salena | 3,827 |
| | Columbus | 3,395 |

Source: Bureau of the Census[2/]

Table VI-2

Study Area Populations
Total, Urban, and Rural 1940, 1950, and 1960

| State | County | 1940 Total | 1940 Urban | 1940 Rural | 1950 Total | 1950 Urban | 1950 Rural | 1960 Total | 1960 Urban | 1960 Rural |
|---|---|---|---|---|---|---|---|---|---|---|
| Missouri | | | | | | | | | | |
| | Barry | 23,546 | 3,819 | 19,727 | 21,755 | 4,031 | 17,724 | 18,921 | 4,115 | 14,806 |
| | Barton | 14,148 | 2,992 | 11,156 | 12,678 | 3,233 | 9,445 | 11,113 | 3,608 | 7,505 |
| | Jasper | 78,705 | 53,833 | 24,872 | 79,106 | 55,482 | 23,624 | 78,863 | 55,317 | 23,546 |
| | Lawrence | 24,637 | 4,632 | 20,005 | 23,420 | 4,893 | 18,527 | 23,260 | 5,927 | 17,333 |
| | Newton | 29,039 | 6,247 | 22,792 | 28,240 | 7,126 | 21,114 | 30,093 | 9,097 | 20,996 |
| Oklahoma | | | | | | | | | | |
| | Ottawa | 35,849 | 14,193 | 21,656 | 32,218 | 15,752 | 16,466 | 28,301 | 15,422 | 12,879 |
| Kansas | | | | | | | | | | |
| | Cherokee | 29,817 | 12,698 | 17,119 | 25,144 | 12,166 | 12,978 | 22,279 | 11,720 | 10,559 |
| | Crawford | 44,191 | 20,125 | 24,066 | 40,231 | 19,341 | 20,890 | 37,032 | 18,678 | 18,354 |
| TOTAL | | 279,932 | 118,539 | 161,393 | 262,792 | 122,024 | 140,768 | 249,862 | 123,884 | 125,978 |
| Percent Total | | | 42.3 | 57.7 | | 46.4 | 53.6 | | 49.5 | 50.5 |

Source: Bureau of the Census[2/]

As indicated in table VI-2, the increase of 5,000 in the urban component of the population between 1940 and 1960 failed to offset the 35,000 loss in the rural component, therefore, net loss of about 30,000 occurred in the study area between 1940 and 1960.

## Resources Within the Area

The study area is served by three major railroads, several U. S. and State highways, and one interstate highway. As shown in table VI-2, about one-half of the 1960 population resided in rural areas.

As shown in table VI-3, the value of farm products in 1964 exceeded $75 million. The value of livestock and livestock products were the leading income producers accounting for about two-thirds of the value of farm products sold. A significant portion of the livestock and livestock product values is a result of the sale of dairy products. In 1964, there were approximately 57,000 dairy cattle in the study area. Most of these were concentrated around the Joplin-Pittsburg and Miami areas. The heaviest concentration is in the Joplin area with dairy product manufactures such as the Carnation Company at Mount Vernon, Milnot at Seneca, Missouri, and Pet Milk at Neosho are markets for their products and secure their raw milk from the local dairies.[14/] Although there was a reduction in the number of farms and acres of cropland harvested, both value of crops and value of livestock sold increased. The main crops sold included wheat, corn, and soybeans.

Table VI-3

Agricultural Statistics for the Study Area
1959 and 1964

| | 1959 | 1964 |
|---|---|---|
| Number of farms | 14,721 | 13,548 |
| Acres of Cropland Harvested | 1,019,841 | 941,278 |
| Value of All Crops Sold | $23,993,083 | $26,184,579 |
| Value of All Livestock and Livestock Products Sold | $43,192,046 | $49,753,964 |
| Total Value of All Farm Products | $67,185,129 | $75,938,543 |

Source: Bureau of the Census[15/]

At one time, mining was a very important industry in the "Tri-State" area. A good portion of the rich deposits of lead and zinc have been depleted in Ottawa, Cherokee, and Newton counties. Most of the remaining minerals left in these counties are not of such quantities and of such quality to promote economical mining. Mining employment decreased from 3,178 in 1950 to 784 in 1960.[16] In the past, strip mining has been quite an important activity in the study area. Although some activity still exists in Cherokee and Crawford counties, coal mining accounts for a very small portion of the economic activity of the area.

## Manufacturing

More than 19,000 or 21.5 percent of the total labor force in 1960 was employed in manufacturing, as shown in table VI-4. The most significant employers include food and kindred products, other nondurables, electrical and other machinery, chemicals and allied products, and transportation equipment. These industries account for more than 75 percent of the total manufacturing employment. The largest manufacturing firms are a Rockadyne plant at Neosho, Missouri which makes rocket engines employing about 1,500; B. F. Goodrich at Miami, Oklahoma which makes rubber tires and employs about 2,200; Vickers, Inc. at Joplin, Missouri which makes hydraulic equipment and employs about 1,500; and Spencer Chemical Company near Joplin, Missouri which makes fertilizer.[14] Most of the manufacturing is concentrated around the cities of Joplin, Carthage, Webb City, Neosho, Missouri; Miami, Oklahoma, and Pittsburg, Kansas.

Table VI-4

Study Area Labor Force and Population
1950 and 1960

| | 1950 | | 1960 | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| Agriculture (Forestry & Fisheries) | 21,111 | 22.1 | 10,448 | 11.7 |
| Mining | 3,178 | 3.3 | 784 | 0.9 |
| Manufacturing, Total | 13,808 | 14.5 | 19,186 | 21.5 |
| Food & Kindred Products | 2,690 | 2.8 | 2,964 | 3.3 |
| Apparel | 2,006 | 2.1 | 2,298 | 2.6 |
| Chemicals & Allied Products | 1,861 | 2.0 | 2,169 | 2.4 |
| Electrical & Other Machinery | 954 | 1.0 | 2,632 | 3.0 |
| Transportation Equipment | 123 | 0.1 | 1,765 | 2.0 |
| Other Nondurables | 1,903 | 2.0 | 2,879 | 3.2 |
| Other Manufacturing | 4,271 | 4.5 | 4,479 | 5.0 |
| Service | 52,937 | 55.5 | 54,020 | 60.7 |
| Unemployed | 4,410 | 4.6 | 4,657 | 5.2 |
| TOTAL LABOR FORCE | 95,444 | 100.0 | 89,095 | 100.0 |
| TOTAL POPULATION | 262,792 | | 249,862 | |
| Labor Force % of Population | | 36.7 | | 36.3 |

Source: Bureau of the Census[16/]

Other Economic Activity

The Joplin, Missouri area is well known as the gateway to the Ozark empire. Most of the tourist traffic which comes from the west or leaves the Ozark's going west goes through the study area. Considerable economic activity is generated by the tourist traffic. The large number of reservoirs within easy driving distance of the study area are a chief reason for the tourist activity in the area. There is also a wide variety of hunting available in the area.

Future

Economic projections are necessary to determine the future municipal, industrial, and water quality control needs of the area. Since the Corps of Engineers was conducting an economic study of the area at the same time as the Federal Water Pollution Control Administration, the following projections reflect a coordinated series of projections for the area.

Future growth is expected to result in expansion of existing industries, entry of new industries in the area, and a continued increase of tourist traffic.

Heavy industrial water-users are expected to be those which are presently located in the study area. They include food and kindred processing, electrical power generation, and chemical plants. As a tool in projecting industrial water requirements, the employment projections in table VI-5 were developed. These projections provide a basis for estimating industrial water use for the years indicated.

Table VI-5

Spring River Study Area
Labor Force Projections 1960, 2000, and 2025

| | 1960 | | 2000 | | 2025 | |
|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent |
| Agriculture (Forestry & Fisheries) | 10,448 | 11.7 | 7,000 | 6.1 | 6,000 | 4.1 |
| Mining | 784 | 0.9 | 500 | 0.4 | 500 | 0.3 |
| Manufacturing | 19,186 | 21.5 | 30,000 | 26.1 | 40,000 | 27.4 |
| Service & Other | 54,020 | 60.86 | 71,700 | 62.4 | 92,900 | 63.7 |
| Unemployed | 4,657 | 5.23 | 5,800 | 5.0 | 6,600 | 4.5 |
| Total Labor Force | 89,095 | 100.0 | 115,000 | 100.0 | 146,000 | 100.0 |
| Total Population | 249,862 | | 320,000 | | 400,000 | |
| Labor Force % of Population | | 35.7 | | 36.0 | | 36.5 |

To provide a framework for analyzing water requirements as well as waste discharges, population projections were disaggregated to a county basis as are shown in table VI-6. For the 50-year period from 2025 to 2075, population is used as an indicator of water requirements. As shown in table VI-6 total population is expected to reach 640,000 by 2075 with more than 85 percent of the projected population residing in urban areas.

Table VI-6

Spring River Study Area Population Projections
2000, 2025, and 2075

| County | 1960 | | 2000 | | 2025 | | 2075 | |
|---|---|---|---|---|---|---|---|---|
| | Total | Urban | Total | Urban | Total | Urban | Total | Urban |
| Barry | 18,921 | 4,115 | 19,000 | 8,000 | 20,000 | 10,000 | 32,000 | 22,000 |
| Barton | 11,113 | 3,608 | 12,000 | 6,000 | 12,000 | 8,000 | 20,000 | 16,000 |
| Jasper | 78,863 | 55,317 | 116,000 | 96,000 | 144,000 | 126,000 | 214,000 | 197,000 |
| Lawrence | 23,260 | 5,927 | 25,000 | 12,000 | 27,000 | 15,000 | 43,000 | 31,000 |
| Newton | 30,093 | 9,097 | 40,000 | 23,000 | 60,000 | 45,000 | 98,000 | 83,000 |
| Ottawa | 28,301 | 15,422 | 38,000 | 30,000 | 50,000 | 45,000 | 94,000 | 89,000 |
| Cherokee | 22,279 | 11,720 | 30,000 | 20,000 | 40,000 | 35,000 | 64,000 | 59,000 |
| Crawford | 37,032 | 18,678 | 40,000 | 25,000 | 47,000 | 35,000 | 75,000 | 63,000 |
| TOTAL | 249,862 | 123,884 | 320,000 | 220,000 | 400,000 | 319,000 | 640,000 | 560,000 |

# VII. WATER REQUIREMENTS

## Present Water Use

### Municipal

Joplin and Neosho, Missouri, utilize Shoal Creek as a source of water supply. All other principal communities in the study area rely on ground water. In 1962, municipal water use amounted to approximately 16 million gallons per day, or an average per capita use of approximately 110 gallons per day. Water use characteristics of the principal communities in the study area are shown in table VII-1.

### Industrial

Most small service and food and kindred products industrial water uses are supplied from municipal systems and are reflected in table VII-1 under municipal water use. The major use of industrial water in the basin besides the food and kindred industry, is by the chemical industry (explosives and fertilizers) and thermo-electric power consumption. The Gulf Oil Corporation's Jayhawks Works near Galina, Kansas withdraws approximately 45 million gallons per day from Spring River to use for cooling.[17] Five chemical industries near Joplin, Missouri use approximately 4 mgd for cooling,[18] most of which is water from abandoned lead and zinc mine. The consumptive water use for the Empire District Electric Company's Riverton Thermo-Electric Plant is approximately 2.5 mgd, estimated from 1966 power output[19] and unit consumptive rates.[20]

## Future Water Use

Projections of future municipal and industrial water use in the Spring River basin is determined by population and industrial growth projections as presented in chapter VI.

Table VII-1

1962 Municipal Water Use

| Municipality | Population Served | Average Use (mgd) | Source |
|---|---|---|---|
| Missouri | | | |
| Monett | 5,400 | 1.00 | 6 wells |
| Lamar | 3,480 | 0.35 | 1 well |
| Webb City | 6,750 | 0.55 | 3 wells |
| Carthage | 11,300 | 1.00 | 7 wells |
| Sarcoxie | 1,055 | 0.10 | 2 wells |
| Mount Vernon | 2,550 | 0.25 | 3 wells |
| Pierce City | 1,175 | 0.13 | 2 wells |
| Aurora | 4,700 | 0.23 | 2 wells |
| Marionville | 1,250 | 0.10 | 1 well |
| Joplin | 39,500 | 5.00 | Shoal Creek |
| Neosho | 8,500 | 1.50 | Shoal Creek |
| Oklahoma | | | |
| Miami | 14,000 | 1.20 | 6 wells |
| Picher | 3,000 | 0.23 | 3 wells |
| Kansas | | | |
| Baxter Springs | 4,550 | 0.75 | 3 wells |
| Galena | 3,900 | 0.35 | 3 wells |
| Columbus | 3,700 | 0.35 | wells |
| Pittsburg | 21,500 | 2.00 | 4 wells |
| Girard | 2,500 | 0.25 | 2 wells |
| Arma | 1,500 | 0.07 | 2 wells |
| Frontenac | 2,000 | 0.18 | 2 wells |

Source: Public Health Service[21/]

## Municipal

Based on future population growth and a per capita demand of 150 gallons per day, which includes water used by service and light industries on municipal systems, presented in table VII-2 is the projected municipal water use in the Spring River basin. Per capita water demand is expected to increase in the future based on current water trends in cities of comparable population to which the study area towns are expected to grow, as well as climate and rainfall factors of the study area, which affect per capita water use.

Table VII-2

Municipal Water Use Projections
(mgd)

| State | County | 2000 | 2025 | 2075 |
|---|---|---|---|---|
| Missouri | Barry | 1.2 | 1.5 | 3.1 |
| | Barton | 0.8 | 1.2 | 2.4 |
| | Jasper | 14.4 | 18.9 | 29.6 |
| | Lawrence | 1.8 | 2.3 | 4.7 |
| | Newton | 3.5 | 6.8 | 12.5 |
| Oklahoma | Ottawa | 4.5 | 6.8 | 13.4 |
| Kansas | Cherokee | 3.0 | 5.3 | 8.9 |
| | Crawford | 3.8 | 5.3 | 9.5 |
| | Totals | 33.0 | 48.1 | 84.1 |

## Industrial

Major industrial water users in the area are expected to continue to be the food and kindred industry, the chemical industry, and thermo-electric power generation. Based on industrial growth presented in chapter VI, ratios of water use to different segments of projected manufacturing employment, and unit water rates of production, [20,21,22] projected industrial water requirements were developed for the study area. They are presented in table VII-3. Included in the thermo-electric power generation demand is a new 200,000 KW plant at Ashbury, Missouri, scheduled for completion by 1970.[19] The existing Riverton plant will be used to provide peaking power until power demands develop in the area to exceed the capacity of the new Ashbury plant.

Table VII-3

Industrial Water Use Projections
(mgd)

| Industry | 2000 | 2025 | 2075 |
|---|---|---|---|
| Chemical and allied products | 63.6 | 80.0 | 107.0 |
| Food and Kindred products | 9.4 | 11.4 | 18.5 |
| Thermo-electric power consumption | 2.1 | 2.7 | 4.4 |
| Total | 75.1 | 94.1 | 129.9 |

## Future Water Use Needs

Due to the abundance of ground water in the study area, supplies are considered adequate to meet future municipal needs. The high dependable flow of Shoal Creek is also considered adequate to continue to meet the municipal demands of Joplin and Neosho, Missouri. The flow of Spring River at Galena, Kansas, is sufficient to meet the expanding needs of the Gulf Oil Corporation chemical plant at Galena. The chemical plants in the Joplin, Missouri vicinity, however, will need to obtain an additional source of water. Their water demands are projected to increase significantly in the future, soon exceeding the dependable yield of their present supply, mine water from abandoned lead and zinc mines. In addition, a high quality surface supply will be more economical than continued use of mine water and treatment for removal of lead, zinc, and other minerals before release to surface streams in order to meet the State of Missouri's water quality standards.

The total municipal and industrial water supply use in the Spring River basin is projected to be 214.0 million gallons per day in the year 2075. This use is expected to be satisfied from three sources: existing and further developed ground water supplies, existing surface supplies, and additional surface water storage to increase stream yields during periods of low runoff, as shown below in table VII-4.

Table VII-4

Municipal and Industrial Water Supply Plan
(million gallons per day)

| 2075 Projected Use | Source | | |
|---|---|---|---|
| | Ground Water | Surface Water | Surface Water Storage |
| 214.0 | 72.0 | 115.0 | 27.0 |

# VIII. WATER QUALITY CONTROL

Water quality control can be defined as any measure employed to enhance the utility, value and attractiveness of waters used for purposes which are adversely affected by changes in water quality. The use of water by man in his many activities and the subsequent return of waste effluent even after secondary treatment, causes some degradation of the water used. As population and the associated water demand increases, and realizing that water is used and reused many times as it travels downstream, the problem caused by waste water becomes more significant. One method of restoring a stream's quality to an acceptable level is the addition of water of better quality to aid in the assimilation of wastes. This report is a study of the needs for and effects of water quality control augmentation flows from the U. S. Army Corps of Engineers multi-purpose reservoir on Center Creek to improve the quality of streamflows in the Spring River basin. The results of this study indicate that water quality control is needed on two streams in the basin: Turkey Creek and Center Creek.

## Turkey Creek

Turkey Creek, flowing along the northern edge of the city of Joplin, receives the treated wastes of the city. Even though the wastes are receiving secondary treatment at a properly operated trickling filter plant, the low natural flows of Turkey Creek are frequently not sufficient to adequately assimilate the wastes, resulting in depressed oxygen conditions and severly limiting the usefullness of Turkey Creek for recreation, fish and wildlife, agriculture, and aesthetics. As the population, and thus, the water use and waste discharge of the city of Joplin increase, the situation on Turkey Creek will become more severe. One method to maintain water quality in Turkey Creek now and in the future would be the augmentation of low streamflows from storage in the Corps of Engineers' multi-purpose project on Center Creek with a pipeline to Turkey Creek. The projected minimum required low flows needed on Turkey Creek to assimilate the waste discharges from the city of Joplin and maintain a minimum of 5.0 mg/l of dissolved oxygen, the Missouri Water Pollution Board Stream Standard,[23] were based on population growth and water use projected in chapters VI and VII. The net additional flow, or the yield needed from storage, is the difference between the minimum required flow and the available 95 percent low flow (once-in-20 years) on Turkey Creek. The provision of additional dilution flow shown in table VIII-1 from storage will thus guarantee a minimum of 5.0 mg/l dissolved oxygen 95 percent of the time, or 19 out of 20 years.

Table VIII-1

Water Quality Control Requirements
Turkey Creek

| | Average Annual Flows | | | |
|---|---|---|---|---|
| | Year 2025 | | Year 2075 | |
| | cfs | Acre Ft./Year | cfs | Acre Ft./Year |
| Minimum Required | 21.4 | 15,500 | 33.8 | 24,500 |
| Net Additional (Draft-on-Storage)* | 15.7 | 11,400 | 27.9 | 20,200 |

* Annual draft-on-storage is the sum of the incremental excesses of needed releases over inflows during a year.

Table VIII-2 presents an estimated monthly release schedule for a percentage of the total annual releases for water quality control on Turkey Creek. This release schedule is not intended to be used as a reservoir operating plan. Actual releases will be dependent upon streamflow quantity and quality conditions as they occur. Table VIII-2 is being provided only as an indication of a possible release pattern.

Table VIII-2

Water Quality Control Monthly Release Schedule
for Turkey Creek

| Month | Percent of Annual Draft-on-Storage |
|---|---|
| January | 0 |
| February | 0 |
| March | 0 |
| April | 5 |
| May | 9 |
| June | 14 |
| July | 23 |
| August | 24 |
| September | 17 |
| October | 6 |
| November | 2 |
| December | 0 |

## Center Creek

Center Creek drains an area of approximately 300 square miles north of Joplin, Missouri, before joining Spring River at the Kansas-Missouri stateline. Several industries discharge wastes to the creek, primarily the fertilizer and explosive industries along Grove Creek (see figure III-1). As mentioned in Chapter V, several fish kills have been reported in Center Creek attributable to chemical pollution.

The most outstanding pollution of Center Creek is the high fluoride concentrations, a maximum of 40 mg/l being recorded near Carterville, Missouri. High fluoride contents in excess of 5.0 mg/l have also been recorded on Spring River at Baxter Springs, Kansas.[8/] The Public Health Service's Drinking Water Standards[24/] shows an optimum range for fluoride concentrations of from 0.7 mg/l to 1.2 mg/l depending on average maximum daily air temperatures (which effects water consumption). This range would be beneficial in reducing dental caries while guarding against excessive fluorides which produces dental fluorosis (mottling of tooth enamel). Waters containing fluorides in the concentrations recorded on Center Creek would eliminate this stream for use as water supply, fish and wildlife, and stock watering.

The Missouri Water Pollution Board's Stream Standards[23/] allow a maximum fluoride concentration of 1.2 mg/l and has notified the industries concerned that treatment must be provided to remove excess fluoride in order that, after allowing for dilution by the 7-day low flow once in 10-years (7-day $Q_{10}$),[25/] this standard would not be exceeded. Based on the present quantity of waste discharged, this would allow a maximum fluoride concentration of approximately 8.0 mg/l. Since the present quality of the effluent is approximately 350 mg/l of fluoride, a removal efficiency of 98 percent would be required. This, however, is not unreasonable as a present treatment for removal of fluorides at these concentrations is treatment with lime to neutralize the hydrofluoric acid* and to precipitate most of the fluorides and sulfates as calcium salts.[27/] The solubility of calcium fluoride, $CaF_2$, is approximately 8 mg/l as measured as fluorine.[28/] Thus, this method of treatment would be both adequate and practical to meet the stream standards.

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* Superphosphate fertilizer is produced by reacting rock phosphate and sulfuric acid. Essentially what is affected is the conversion of fluorapatite into mono-calcium phosphate, which is more soluble and therefore more readily available to the crops to which it is applied, and to calcium sulfate and hydrofluoric acid.[26/]

The Corps of Engineers multi-purpose reservoir under study is assumed to have a project life of at least 100 years. Therefore, it was necessary to evaluate the water quality control need for Center Creek for the 100-year life of the project. As discussed in Chapters VI and VII, the chemical industries in the Spring River basin are projected to grow significantly in the future. Their waste discharges and resultant pollution problems are likewise projected to increase.

With an increase in waste discharges, the assimilative capacity of Center Creek will again be exceeded, even though a high degree of treatment is provided the wastes. To maintain water quality at acceptable limits, additional dilution flow could be provided from storage in the Corps of Engineer's multi-purpose reservoir on Center Creek. The minimum flow required to maintain the allowable fluoride concentration of 1.2 mg/l in Center Creek in the futue and the net additional flow needed from storage to satisfy the minimum requirements 19 out of 20 years is given below in table VIII-3.

Table VIII-3

Water Quality Control Requirements
Center Creek

| | Average Annual Flows | | | |
|---|---|---|---|---|
| | Year 2025 | | Year 2075 | |
| | cfs | Acre Ft./Year | cfs | Acre Ft./Year |
| Minimum Required | 40.8 | 29,500 | 54.4 | 39,400 |
| Net Additional (Draft-on-storage) | 11.6 | 8,400 | 20.7 | 15,000 |

Table VIII-4 presents an estimated monthly release schedule as a percentage of the total annual releases for water quality control on Center Creek. Actual releases will be dependent upon streamflow quantity and quality conditions as they occur. Table VIII-4 is only an indication of a possible release pattern.

Table VIII-4

Water Quality Control Monthly Release Schedule for Center Creek

| Month | Percent of Annual Draft-on-Storage |
|---|---|
| January | 11 |
| February | 10 |
| March | 6 |
| April | 3 |
| May | 0 |
| June | 3 |
| July | 5 |
| August | 13 |
| September | 13 |
| October | 14 |
| November | 11 |
| December | 11 |

## Summary

A study of the water quality needs of the Spring River basin indicates that waters released from storage in the Corps of Engineers project on Center Creek are needed to enhance and maintain the quality of surface waters in the basin now and in the future. A total of 35,200 acre-feet per year draft-on-storage will satisfy the needs of the basin through the year 2075, the end of the study period. Of this amount, 20,200 acre-feet per year will be needed for Turkey Creek and 15,000 acre-feet per year will be needed on Center Creek. The proposed yield for water quality control of the current project under study is 28,500 acre-feet per year (25.5 mgd). This amount will satify the quality needs of the basin through approximately the year 2060.

# IX. BENEFITS

## Water Supply Benefits

The actual benefits for developing the water resources of the Spring River basin for water supply result from the provision of an adequate and dependable source of water for future population and industrial growth projected for the city of Joplin, Missouri, and vicinity.

A measure of the benefits that can be obtained by including storage for water supply in the proposed project can be estimated as the cost of supplying the water demands by the most likely alternative means that would be utilized in the absence of the project.

The most likely alternative that would be utilized to supply the increasing water demands in the Joplin area would be a single-purpose water supply project on Shoal Creek at river mile 47.5. The first cost of a reservoir on Shoal Creek to yield 27 mgd is estimated at $7,563,000.[1/] The annual operation and maintenance costs and major replacement costs would be $33,000 and $1,500, respectively.[1/] Financing the first cost over a 100-year period at 3 1/4 percent interest rate yields an average annual charge of $256,200. Including the annual operation and maintenance and replacement costs, the most likely alternate to water supply storage in the multi-purpose project on Center Creek, a single-purpose project on Shoal Creek, would have an average annual cost of $290,700.

The annual value of benefits for water supply storage in the proposed Center Creek Reservoir is estimated as the average annual cost of the most likely alternative to this storage, or $290,700.

## Water Quality Control Benefits

The benefits attributable to storage in Federal reservoirs for water quality control are defined as the net contribution to public health, safety, economy, and effectiveness in use, and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of change in water quality.

The benefits of improving the quality of water in Center and Turkey Creeks arise primarily from the increased value of recreation, including fishing and wildlife, and aesthetics to the population of the Joplin vicinity.

One method of estimating the benefits for water quality storage in the multi-purpose project on Center Creek is to determine the

cost of the least costly alternative for water quality control that would be utilized in absence of storage in the Federal reservoir. Two alternates that were considered were water quality control storage in a single-purpose reservoir and advanced waste treatment of the municipal and industrial wastes.

## Single-Purpose Reservoir Alternate

A single-purpose water quality control reservoir at river mile 18.0 on Center Creek with a pipeline to Turkey Creek would be the least costly water quality storage alternate. A reservoir on Center Creek to yield 25.5 mgd for water quality control would have a first cost of $15,207,000. This cost amortized over the 100-year life of the project at 3 1/4 percent results in an annual charge of $515,200. The annual operation and maintenance charges and major replacement costs are $76,000 and $3,400, respectively. The total annual cost of this reservoir is the sum of these three annual costs, or $594,600.[1/]

The first cost of a pipeline from the single-purpose reservoir on Center Creek to Turkey Creek, 4.24 miles of 42" reinforced concrete pipe, would be $1,400,000. This cost financed at 3 1/4 percent over 100 years yields an annual charge of $47,400. Adding to this amount the annual operation and maintenance costs ($14,000), the annual major replacement costs ($1,300), and the annual pumping costs ($14,900) gives a total annual pipeline cost of $77,600.[1/]

The total annual cost of the single-purpose water quality control reservoir alternate, including a pipeline to Turkey Creek, is therefore $672,200.

## Advanced Waste Treatment Alternate

### Turkey Creek

Due to the extreme low flows on Turkey Creek, the Joplin municipal wastes would require a high degree of treatment to prevent serious quality degradation in the stream in the absence of dilution flow releases. The degree of treatment needed by months is shown below for the years 1975, 2025, and 2060.

Table IX-1

Treatment Requirements
Turkey Creek
(%)

| Month | Treatment Required 1975 | 2025 | 2060 |
|---|---|---|---|
| January | 90 | 90 | 90 |
| February | 90 | 90 | 90 |
| March | 90 | 90 | 90 |
| April | 91 | 94 | 95 |
| May | 92 | 95 | 96 |
| June | 94 | 96 | 97 |
| July | 97 | 98 | 98 |
| August | 98 | 98 | 98 |
| September | 97 | 98 | 98 |
| October | 93 | 95 | 96 |
| November | 90 | 93 | 94 |
| December | 90 | 90 | 90 |

In order to achieve 98 percent treatment, secondary treatment of the wastes would be followed by lime-alum coagulation, sedimentation and rapid sand filtration, then by activated carbon adsorption.[29/] During the months that 98 percent treatment is not required, a portion of the total effluent could be treated to this degree and then mixed with the remaining portion treated to 90 percent to obtain the required final degree of treatment of the total effluent. Based on a capital cost of 25 cents per daily gallon capacity, and 11 cents per 1,000 gallons treated operating costs, including chemicals,[29/] the total average annual cost of advanced waste treatment for Joplin's effluent is estimated at $222,200, as calculated below. For economic reasons, the advanced waste treatment facility was constructed in two stages: First stage in 1975 with sufficient capacity until the year 2000, the second stage constructed in 2000 with additional capacity sufficient through the year 2060.

| | |
|---|---|
| 1975 System: 7 mgd | |
| Capital Cost: | |
| 7 mgd x 25¢/gallon | $ 1,750,000 |
| Annual Costs: | |
| Amortize 100 years @ 3½ percent | 59,300 |
| Operating cost: | |
| 2.80 mgd x 11¢/1,000 gallons x 365 days/year | 112,400 |
| Total Annual Cost | $ 171,700 |
| 2000 System: Add 5.7 mgd | |
| Capital Cost: | |
| 5.7 mgd x 25¢/gallon | $ 1,425,000 |
| Annual Cost: | |
| Amortize 100 years @ 3½ percent | 48,300 |
| Operating cost: | |
| 1.94 mgd x 11¢/1,000 gallons x 365 days/year | 77,900 |
| Total Annual Cost | $ 126,200 |
| Capitalized cost for 60 year period, | |
| 2000 - 2060: | $ 3,313,000 |
| Discount 25 years | 1,489,000 |
| Amortize 100 years @ 3½ percent | 50,500 |
| 1975 Annual cost of 2000 system | $ 50,500 |
| Total Annual Cost of Advanced Waste Treatment: | |
| 1975 System | $ 171,700 |
| 2000 System | 50,500 |
| Total | $ 222,200 |

Center Creek

As the quantity of industrial waste discharges increase, the degree of waste treatment efficiency must increase in order to maintain high quality conditions in the absence of augmented low flows. Allowable fluoride concentrations discharged will vary according to streamflow, but allowable average annual concentrations will decrease from approximately 8 mg/l in 1975 to 5 mg/l in the year 2000, and 3 mg/l in 2075.

One defluoridation method successfully being used at the present[30/] involves activated alumina in the form of an insoluable granular media which removes the fluorides as the water percolates through them. The media is periodically regenerated by back-washing with sodium hydroxide solution, raw water, then a weak sulfuric acid solution. Based on a capital cost of $54,000 per mgd capacity, and operating costs, including chemicals, of $50 per mgd treated,[30/] the cost of additional treatment of fluorides wastes discharged into Center Creek to maintain quality conditions in lieu of dilution flow releases would be $43,300 annually over the life of the project.

The total annual cost for an alternate of advanced waste treatment of wastes entering both Turkey and Center Creeks is the sum of both annual cost, $222,200 and $43,300, or $265,500.

The annual benefits attributed to storage and transmission facilities for water quality control in the Spring River basin is estimated as the cost of the least costly alternative, advanced waste treatment ($265,500). The benefits for water quality storage in the study project is therefore estimated as the cost of the least costly alternative less the cost of transmission facilities ($77,600), or $187,900 annually.

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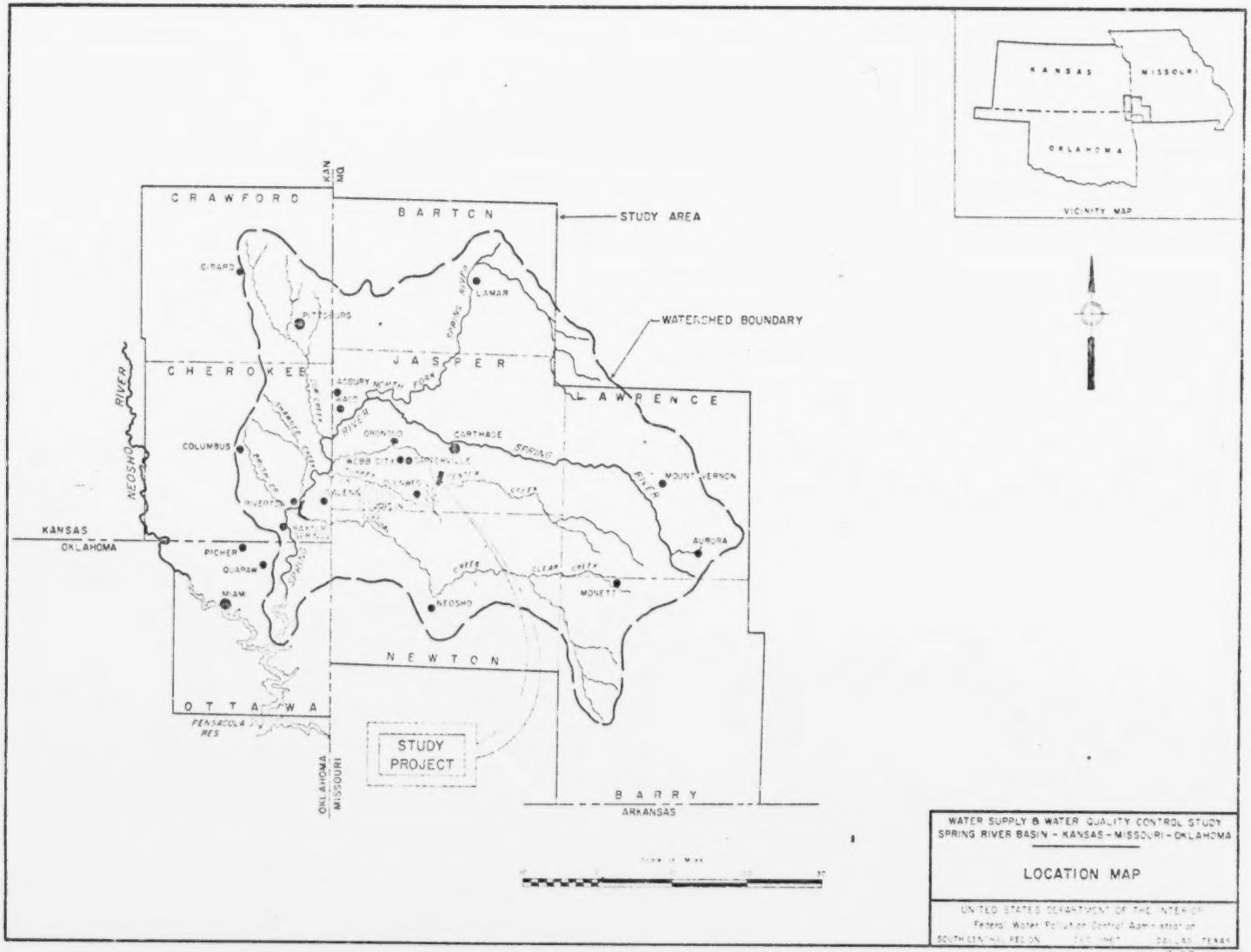


WATER SUPPLY & WATER QUALITY CONTROL STUDY
SPRING RIVER BASIN - KANSAS - MISSOURI - OKLAHOMA

LOCATION MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION DALLAS, TEXAS

FIGURE III-1